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Boysel et al.

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(54) **KNOCKOUT FOR USE WHILE NECKING A METAL CONTAINER, DIE SYSTEM FOR NECKING A METAL CONTAINER AND METHOD OF NECKING A METAL CONTAINER**

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CPC ***B21D 51/2669*** (2013.01); ***B21D 37/00*** (2013.01); ***B21D 41/04*** (2013.01); ***B21D 51/2638*** (2013.01)

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USPC 72/344, 345, 427, 715, 347, 349
See application file for complete search history.

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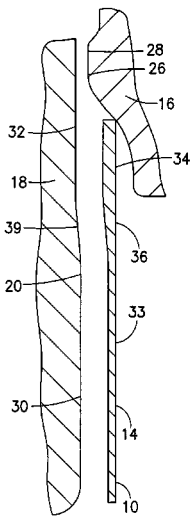
(57) **ABSTRACT**

A knockout has a support surface and the support surface has: (i) a first knockout outer diameter capable of supporting the first inner diameter of a container side wall when the knockout is inserted into an opening of the metal container and when the metal container is being necked with a necking die; and (ii) a second knockout outer diameter capable of supporting the second inner diameter of the container side wall when the knockout is inserted into the opening of the metal container and when the metal container is being necked with the necking die, and wherein the first knockout outer diameter is larger than the second knockout outer diameter.

21 Claims, 5 Drawing Sheets



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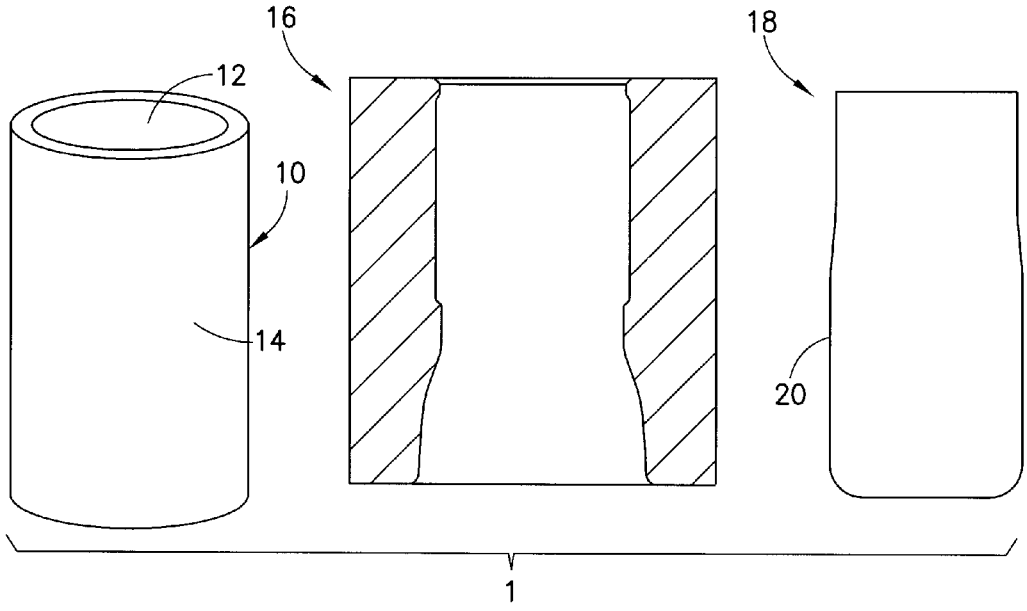


FIG. 1

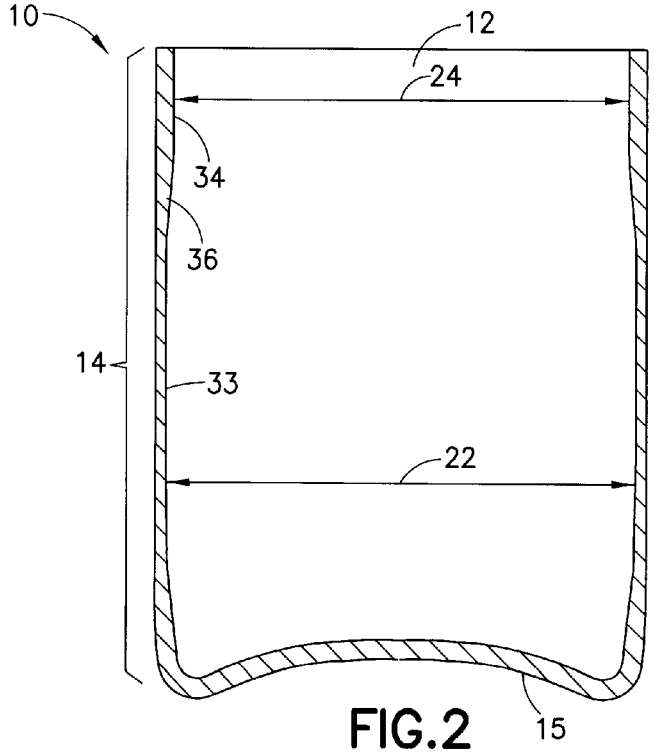


FIG. 2

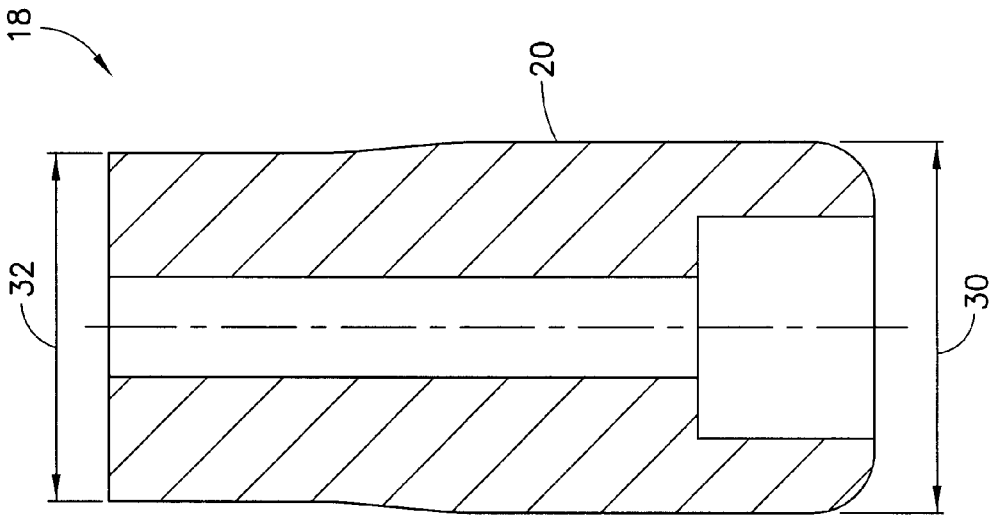


FIG.4

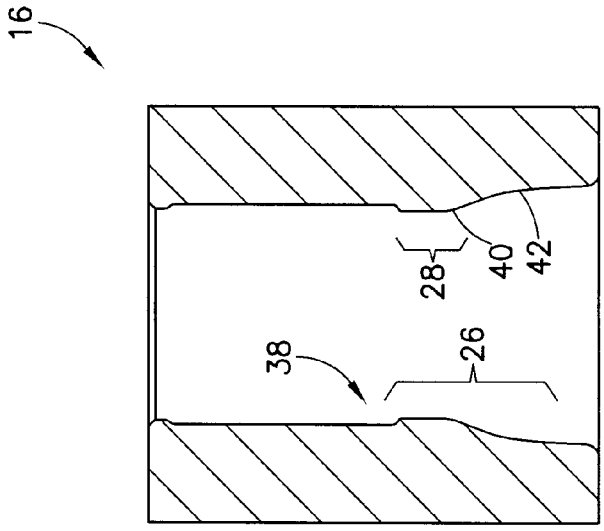


FIG.3

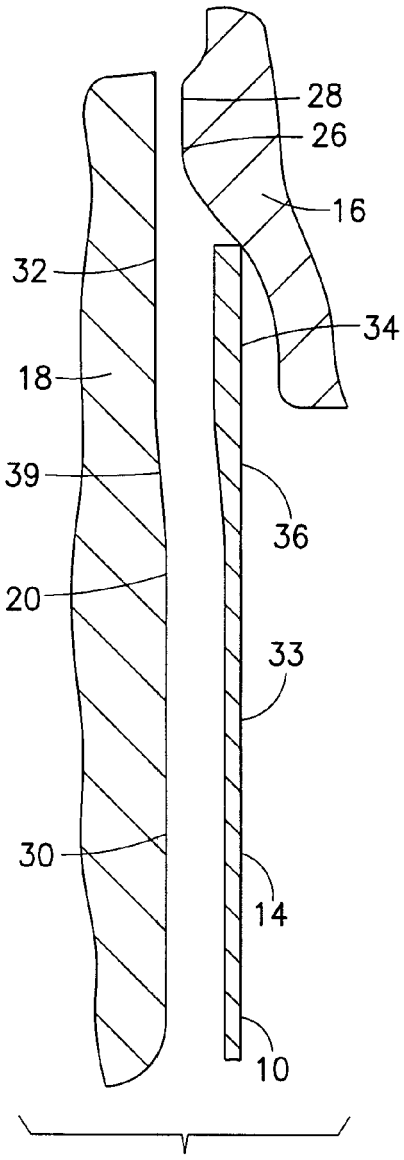


FIG.5

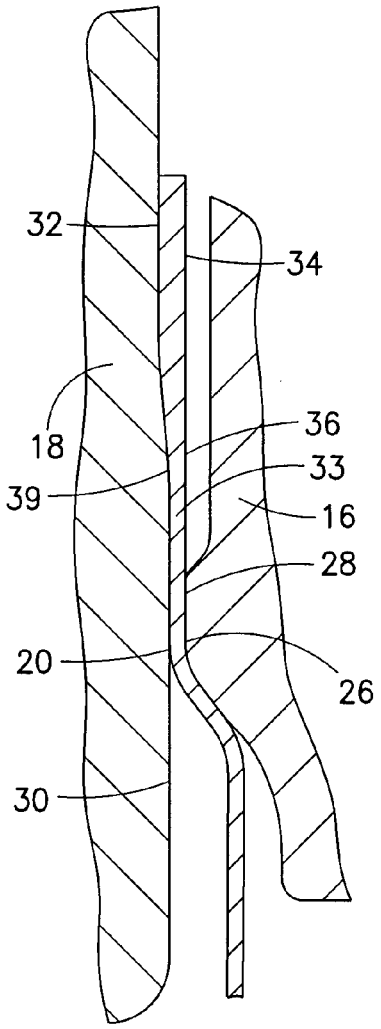


FIG.6

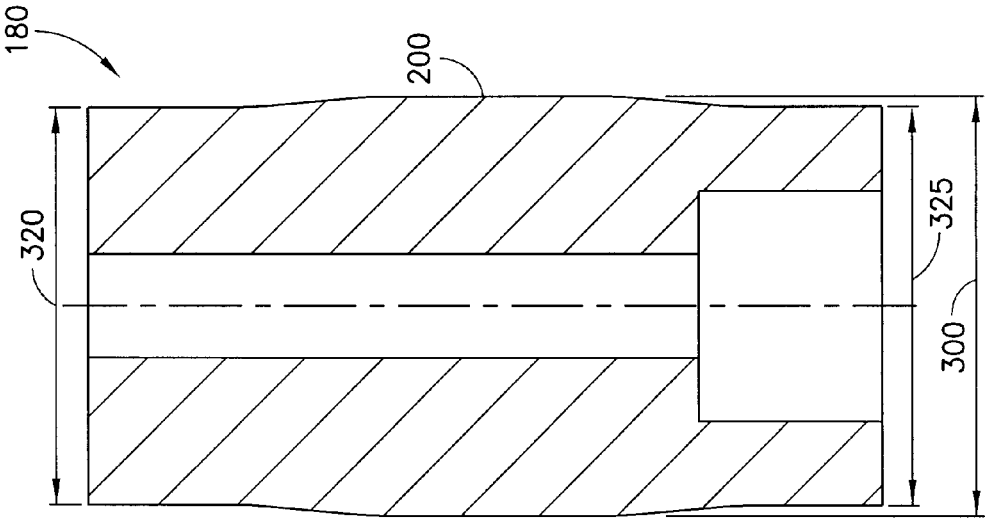


FIG.8

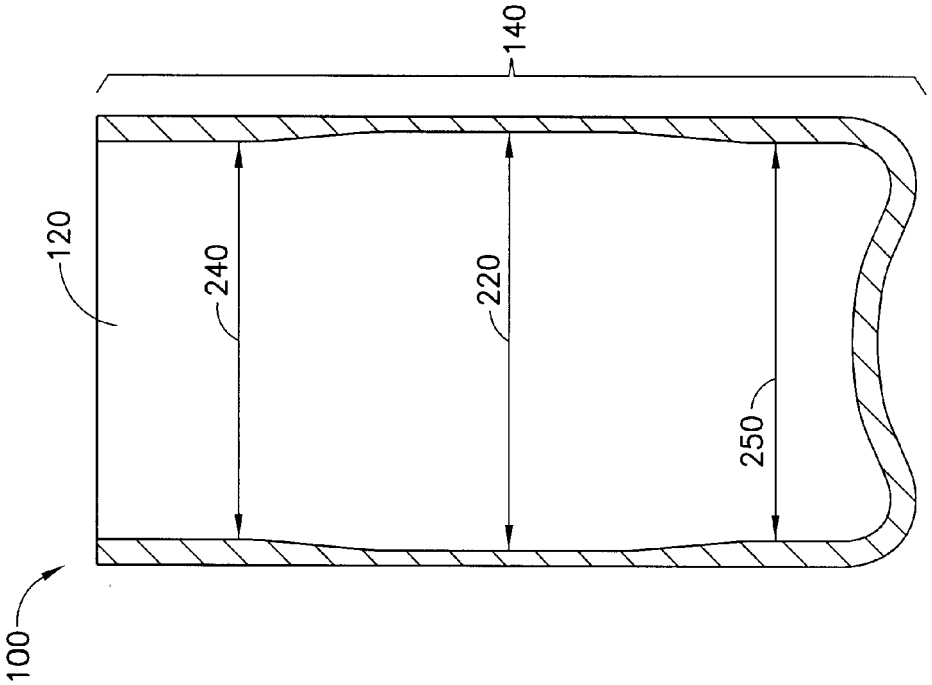
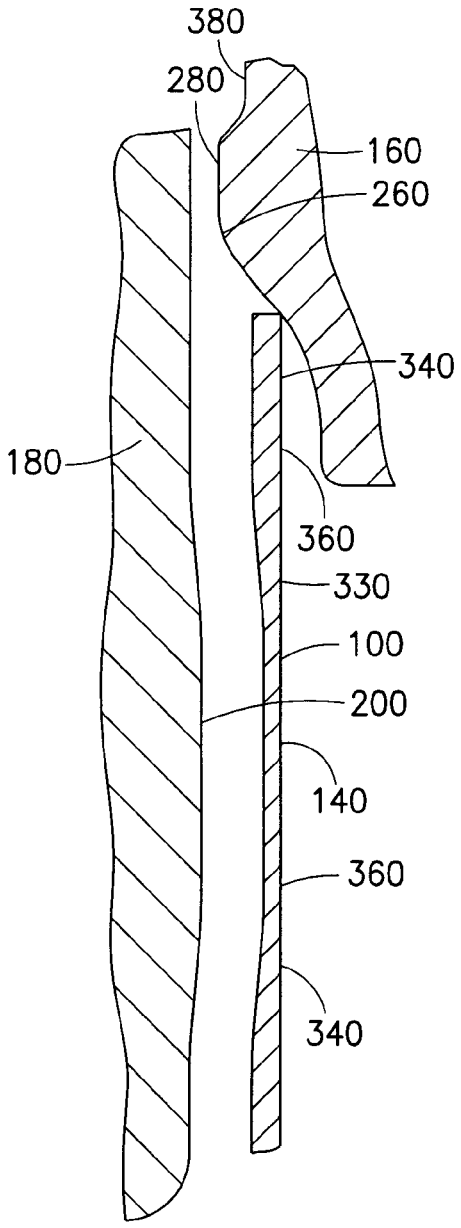


FIG.7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160
260
340
180
360
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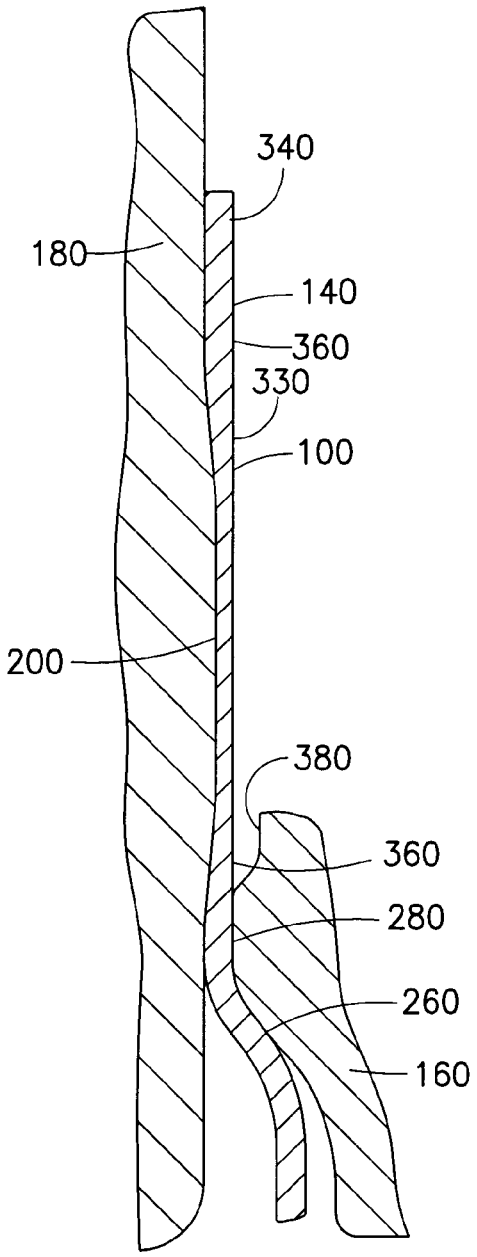
100
200
140
360
340

FIG.9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160

FIG.10

KNOCKOUT FOR USE WHILE NECKING A METAL CONTAINER, DIE SYSTEM FOR NECKING A METAL CONTAINER AND METHOD OF NECKING A METAL CONTAINER

BACKGROUND

It is well-known to neck the top side wall of drawn and ironed metal containers with a necking die to narrow the opening of the metal containers to accept a lid or to form the metal container into a bottle. Necking the top side wall of drawn and ironed metal containers requires a knockout, which works in harmony with the necking die.

SUMMARY

One embodiment of a die system comprises a metal container, a necking die and a knockout. The metal container has an opening and a container side wall. The container side wall has a first inner diameter and a second inner diameter, wherein the first inner diameter of the container side wall is at least 0.001 inches greater than the second inner diameter of the container side wall. The necking die has a working surface comprising a land. The knockout has a support surface. The support surface has a first knockout outer diameter capable of supporting the first inner diameter of the container side wall when the knockout is inserted into the opening of the metal container and when the metal container is being necked with the necking die; and a second knockout outer diameter capable of supporting the second inner diameter of the container side wall when the knockout is inserted into the opening of the metal container and when the metal container is being necked with the necking die. The first knockout outer diameter is larger than the second knockout outer diameter.

The metal container may be any type of metal container including beverage cans and cups, aerosol cans and food containers. The metal container can be made by any process known in the art including but not limited to: drawing and ironing; impact extrusion; spin forming; draw and redraw; and deep drawing.

A container side wall is the body of the container as shown in FIG. **2**.

A necking die is a die used to narrow a diameter of a metal container via axial movement with respect to the metal container.

A working surface of the necking die is the surface of the necking die that directly contacts a metal container when the necking die is narrowing a diameter of the metal container.

A land is the portion of the inner diameter of the working surface of the necking die having the smallest inner diameter.

A knockout, also known as a pilot, fits inside the metal container during necking and provides a support surface against which the working surface of the necking die pushes the metal container during necking. In some embodiments the knockout helps the container to be removed from the die after necking. The knockout moves coaxially relative to the necking die.

A support surface of the knockout is capable of supporting the metal container during necking and prevents the metal container from wrinkling, buckling, rupturing or other defects when the metal container is being narrowed with the necking die.

In some embodiments, capable of supporting means that during necking and when the knockout is inserted or partially inserted into the metal container the clearance between the knockout and the portions of the side wall of the metal container being necked by the necking die is 0.0005 inch or less as the necking die is narrowing said portions. The maximum clearance between the knockout and the portions of the side wall of the metal container being necked by the necking die that is capable of supporting will depend on alloy, temper, thickness, and variation in thickness of the metal container.

In some embodiments, capable of supporting means that during necking and when the knockout is inserted or partially inserted into the metal container the clearance between the knockout and the portions of the side wall of the metal container being necked by the necking die is 0.003 inch or less as the necking die is narrowing said portions.

In some embodiments, capable of supporting means that during necking and when the knockout is inserted or partially inserted into the metal container the clearance between the knockout and the portions of the side wall of the metal container being necked by the necking die is 0.002 inch or less as the necking die is narrowing said portions.

In some embodiments, capable of supporting means that during necking and when the knockout is inserted or partially inserted into the metal container the clearance between the knockout and the portions of the side wall of the metal container being necked by the necking die is 0.0015 inch or less as the necking die is narrowing said portions.

In some embodiments, capable of supporting means that during necking and when the knockout is inserted or partially inserted into the metal container the clearance between the knockout and the portions of the side wall of the metal container being necked by the necking die is 0.001 inch or less as the necking die is narrowing said portions.

In some embodiments of the die system, the second inner diameter of the container side wall is closer to the opening of the metal container than the first inner diameter of the container side wall. In some embodiments of the die system, the first knockout outer diameter is capable of passing through the second inner diameter of the side wall after necking when extracting the knockout from the metal container. In some embodiments of the die system, the first inner diameter of the container side wall is at least 0.0015 inches greater than the second inner diameter of the container side wall. In some embodiments of the die system, the first inner diameter of the container side wall is at least 0.002 inches greater than the second inner diameter of the container side wall. In some embodiments of the die system, the first inner diameter of the container side wall is at least 0.0025 inches greater than the second inner diameter of the container side wall. In some embodiments of the die system, the first inner diameter of the container side wall is at least 0.003 inches greater than the second inner diameter of the container side wall. In some embodiments of the die system, the first inner diameter of the container side wall is at least 0.004 inches greater than the second inner diameter of the container side wall. In some embodiments of the die system, the first inner diameter of the container side wall is at least 0.005 inches greater than the second inner diameter of the container side wall.

In some embodiments of the die system, the necking die further comprises a relief; wherein the working surface further comprises a neck radius portion and a shoulder radius portion; wherein the land, neck radius portion, and the shoulder radius portion each have an inner diameter; wherein the land is between the neck radius portion and the relief and the inner diameter of the land is a minimum diameter of the necking die; wherein the inner diameters of the neck radius portion and the shoulder radius portion are greater than the inner diameter of the land; wherein the relief comprises a relief surface; wherein an inner diameter of the relief surface is at least about 0.01 inches greater than the inner diameter of

the land portion; wherein the inner diameter of the relief surface is no greater than a maximum diameter so as to reduce but not eliminate frictional contact between the metal container and the relief surface while maintaining necking performance when necking the metal container; and wherein the necking die is dimensioned so that when necking the metal container, the entire land and the relief travel relative to the metal container in an axial direction and at least a portion of the relief travels into the opening of the metal container. In some embodiments of the die system, the metal container has a closed bottom. In some embodiments of the die system, the metal container was formed by drawing and ironing.

In some embodiments of the die system, there is a smooth transition between the first inner diameter of the container side wall and the second inner diameter of the container side wall. A smooth transition means linear taper from one sidewall thickness to another.

In some embodiments of the die system, the first knockout outer diameter is at least 0.001 inches greater than the second knockout outer diameter. In some embodiments of the die system, the first knockout outer diameter is at least 0.0015 inches greater than the second knockout outer diameter. In some embodiments of the die system, the first knockout outer diameter is at least 0.002 inches greater than the second knockout outer diameter. In some embodiments of the die system, the first knockout outer diameter is at least 0.0025 inches greater than the second knockout outer diameter. In some embodiments of the die system, the first knockout outer diameter is at least 0.003 inches greater than the second knockout outer diameter. In some embodiments of the die system, the first knockout outer diameter is at least 0.004 inches greater than the second knockout outer diameter. In some embodiments of the die system, the first knockout outer diameter is at least 0.005 inches greater than the second knockout outer diameter.

In some embodiments of the die system, the first inner diameter of the container side wall is no more than 0.006 inches greater than the second inner diameter of the container side wall. In some embodiments of the die system, the first inner diameter of the container side wall is no more than 0.005 inches greater than the second inner diameter of the container side wall. In some embodiments of the die system, the first inner diameter of the container side wall is no more than 0.004 inches greater than the second inner diameter of the container side wall.

In some embodiments of the die system, the first knockout outer diameter is no more than 0.006 inches greater than the second knockout outer diameter. In some embodiments of the die system, the first knockout outer diameter is no more than 0.005 inches greater than the second knockout outer diameter. In some embodiments of the die system, the first knockout outer diameter is no more than 0.004 inches greater than the second knockout outer diameter.

In some embodiments of the die system, the transition between the first inner diameter of the container side wall and the second inner diameter of the container side wall substantially matches the transition between the first knockout outer diameter and the second knockout outer diameter. "Substantially matches" means the profile of the knockout at the transition mirrors the transition of the inner diameter of the container side wall, i.e. the distance between the outer diameter of the knockout and the inner diameter of the container side wall remain constant along the height of their respective transitions. In some embodiments of the die system, the container side wall has a third inner diameter and the support surface of the knockout has a third knockout outer diameter capable of supporting the third inner diameter of the container side wall when the knockout is inserted into the opening of the metal container and when the metal container is being necked with the necking die.

In some embodiments, the inner diameter container side wall is tapered and/or comprises multiple tapered segments.

One embodiment of a method of necking a metal container comprises: (A) moving a necking die over an open end of a metal container, wherein the necking die comprises a working surface having a land, and wherein the metal container comprises; (i) an opening; and (ii) a side wall, wherein the side wall has: (a) a first inner diameter; and (b) a second inner diameter; wherein the first inner diameter is at least 0.001 inches greater than the second inner diameter; (B) inserting a knockout into the opening of the metal container, wherein the knockout comprises: (i) a first knockout outer diameter capable of supporting the first inner diameter of the side wall when the knockout is inserted into the opening of the metal container and when the necking die is over the open end of the metal container; and (ii) a second knockout outer diameter capable of supporting the second inner diameter of the side wall when the knockout is inserted into the opening of the metal container and when the necking die is over the open end of the metal container, wherein the first knockout outer diameter is larger than the second knockout outer diameter, (C) removing the necking die from the metal container; and (D) removing the knockout from the metal container; wherein when removing the knockout from the metal container the first knockout outer diameter passes through the second inner diameter of the side wall.

In one embodiment of the method, the inserting the knockout step (B) occurs before the moving the necking die over the open end of the metal container step (A).

In one embodiment of the method, the removing the necking die from the metal container step (C) occurs before the removing the knockout from the metal container step (D).

In one embodiment of the method, the second inner diameter of the container side wall is closer to the opening of the metal container than the first inner diameter of the container side wall.

In some embodiments of the method, the first inner diameter of the container side wall is at least 0.0015 inches greater than the second inner diameter of the container side wall. In some embodiments of the method, the first inner diameter of the container side wall is at least 0.002 inches greater than the second inner diameter of the container side wall. In some embodiments of the method, the first inner diameter of the container side wall is at least 0.0025 inches greater than the second inner diameter of the container side wall. In some embodiments of the method, the first inner diameter of the container side wall is at least 0.003 inches greater than the second inner diameter of the container side wall. In some embodiments of the method, the first inner diameter of the container side wall is at least 0.004 inches greater than the second inner diameter of the container side wall. In some embodiments of the method, the first inner diameter of the container side wall is at least 0.005 inches greater than the second inner diameter of the container side wall.

In one embodiment of the method, the necking die further comprises a relief and the working surface of the necking die further comprises a neck radius portion and a shoulder radius portion; wherein the land, neck radius portion, and the shoulder radius portion each having an inner diameter; wherein the land is between the neck radius portion and the relief and the inner diameter of the land is a minimum diameter of the necking die; wherein the inner diameters of the neck radius portion and the shoulder radius portion are greater than the inner diameter of the land; wherein the relief comprises a

relief surface; wherein an inner diameter of the relief surface is at least about 0.01 inches greater than the inner diameter of the land portion; wherein the inner diameter of the relief surface is no greater than a maximum diameter so as to reduce but not eliminate frictional contact between the metal container and the relief surface while maintaining necking performance when necking the metal container; and wherein the necking die is dimensioned so that when necking the metal container, the entire land and the relief travel relative to the metal container in an axial direction and at least a portion of the relief travels into the opening of the metal container.

In some embodiments of the method, the metal container has a closed bottom. In some embodiments of the method, the metal container was formed by drawing and ironing.

In some embodiments of the method, there is a smooth transition between the first inner diameter of the container side wall and the second inner diameter of the container side wall.

In some embodiments of the method, the first knockout outer diameter is at least 0.001 inches greater than the second knockout outer diameter. In some embodiments of the method, the first knockout outer diameter is at least 0.002 inches greater than the second knockout outer diameter.

In some embodiments of the method, the first inner diameter of the container side wall is no more than 0.006 inches greater than the second inner diameter of the container side wall. In some embodiments of the method, the first inner diameter of the container side wall is no more than 0.005 inches greater than the second inner diameter of the container side wall. In some embodiments of the method, the first inner diameter of the container side wall is no more than 0.004 inches greater than the second inner diameter of the container side wall.

In some embodiments of the method, the first knockout outer diameter is no more than 0.006 inches greater than the second knockout outer diameter. In some embodiments of the method, the first knockout outer diameter is no more than 0.005 inches greater than the second knockout outer diameter. In some embodiments of the method, the first knockout outer diameter is no more than 0.004 inches greater than the second knockout outer diameter.

In some embodiments of the method, the transition between the first inner diameter of the container side wall and the second inner diameter of the container side wall substantially matches the transition between the first knockout outer diameter and the second knockout outer diameter.

In some embodiments of the method, the container side wall has a third inner diameter and wherein the support surface of the knockout has a third knockout outer diameter capable of supporting the third inner diameter of the container side wall when the knockout is inserted into the opening of the metal container and when the metal container is being necked with the necking die.

One embodiment of a knockout comprises: a first knockout outer diameter capable of supporting a first inner diameter of a side wall of a metal container when the knockout is inserted into an opening of the metal container and when the metal container is being necked with a necking die; and a second knockout outer diameter capable of supporting a second inner diameter of the side wall when the knockout is inserted into the opening of the metal container and when the metal container is being necked with the necking die, wherein the first knockout outer diameter is at least 0.001 inch larger than the second knockout outer diameter.

In some embodiments of the knockout, the first knockout outer diameter is capable of passing through the second inner diameter of the side wall after necking when extracting the knockout from the metal container.

In some embodiments of the knockout, the first knockout outer diameter is at least 0.002 inch greater than the second knockout outer diameter.

In some embodiments of the knockout, the metal container has a closed bottom. In some embodiments of the knockout, the metal container was formed by drawing and ironing.

In some embodiments of the knockout, there is a smooth transition between the first knockout outer diameter and the second knockout outer diameter.

In some embodiments of the knockout, the first knockout outer diameter is no more than 0.006 inches greater than the second knockout outer diameter.

In some embodiments of the knockout, the first knockout outer diameter is no more than 0.005 inches greater than the second knockout outer diameter. In some embodiments of the knockout, the first knockout outer diameter is no more than 0.004 inches greater than the second knockout outer diameter.

In some embodiments of the knockout, the transition between the first knockout outer diameter and the second knockout outer diameter substantially matches the transition between the first inner diameter of the side wall and the second inner diameter of the side wall.

In some embodiments of the knockout, the knockout has a third knockout outer diameter capable of supporting a third inner diameter of the side wall when the knockout is inserted into the opening of the metal container and when the metal container is being necked with the necking die.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a die system including a side view of a pre-form metal container, a side cross-sectional view of a necking die and a side cross-sectional view of knockout according to one embodiment;

FIG. **2** is a side cross-sectional view of the pre-form metal container of FIG. **1**;

FIG. **3** is a side cross-sectional side view of the necking die of FIG. **1**;

FIG. **4** is a side cross-sectional side view of the knockout of FIG. **1**;

FIG. **5** is a partial side cross-sectional view of the pre-form metal container, the necking die and the knockout of FIG. **1** as the necking die is about to narrow the pre-form metal container;

FIG. **6** is a partial side cross-sectional view of the pre-form metal container, the necking die and the knockout of FIG. **1** as the necking die is narrowing the metal container;

FIG. **7** is a side cross-sectional side view of a pre-form metal container according to another embodiment;

FIG. **8** is a side cross-sectional side view of a knockout according to another embodiment;

FIG. **9** is a partial side cross-sectional view of the pre-form metal container of FIG. **7**, the knockout of FIG. **8** and a necking die as the necking die is about to narrow the pre-form metal container; and

FIG. **10** is a partial side cross-sectional view of the pre-form metal container of FIG. **7**, the knockout of FIG. **8** and a necking die as the necking die is narrowing the metal container.

DESCRIPTION

For the purposes of this specification, terms such as top, bottom, below, above, under, over, etc. are relative to the position of a finished metal container wherein the base of the

metal container is resting on a flat surface, regardless of the orientation of the metal container during manufacturing or forming steps or processes. A finished metal container is a metal container that will not undergo additional forming steps before it is used by an end consumer. In some embodiments, the top of the container has an opening.

FIG. **1** shows a die system **1** according to one embodiment of the invention. In this embodiment, the die system **1** comprises a metal container **10**, a necking die **16** and a knockout **18**. The metal container **10** has an opening **12** and a container side wall **14**. The knockout **18** comprises a support surface **20**.

FIG. **2** illustrates the metal container **10** in more detail. The metal container **10** has a closed bottom forming a base **15**. The container side wall **14** has a first inner diameter **22** and a second inner diameter **24**, wherein the first inner diameter **22** of the container side wall **14** is at least 0.001 inches greater than the second inner diameter **24** of the container side wall **14**. The portion of the side wall **14** of the container **10** having the first inner diameter **22** is referred to a thin wall **33**. The portion of the side wall **14** of the container **10** having the second inner diameter **22** is referred to a thick wall **34**. There is a smooth transition **36** between the first inner diameter **22** of the container side wall **14** and the second inner diameter **24** of the container side wall **14** and also between the thin wall **33** and the thick wall **34**. In some embodiments, the first inner diameter **22** of the container side wall **14** is at least 0.0015 inches greater than the second inner diameter **24** of the container side wall **14**. In some embodiments, the first inner diameter **22** of the container side wall **14** is at least 0.002 inches greater than the second inner diameter **24** of the container side wall **14**. In some embodiments, the first inner diameter **22** of the container side wall **14** is at least 0.0025 inches greater than the second inner diameter **24** of the container side wall **14**. In other embodiments, the first inner diameter **22** of the container side wall **14** is at least 0.003 inches greater than the second inner diameter **24** of the container side wall **14**. In some embodiments, the first inner diameter **22** of the container side wall **14** is at least 0.004 inches greater than the second inner diameter **24** of the container side wall **14**. In some embodiments, the first inner diameter **22** of the container side wall **14** is at least 0.005 inches greater than the second inner diameter **24** of the container side wall **14**.

As can be observed in the illustrated embodiment, the second inner diameter **24** of the container side wall **14** is closer to the opening **12** of the metal container **10** than the first inner diameter **22** of the container side wall **14**.

In some embodiments of the die system, the first inner diameter of the container side wall is no more than 0.006 inches greater than the second inner diameter of the container side wall. In some embodiments of the die system, the first inner diameter of the container side wall is no more than 0.005 inches greater than the second inner diameter of the container side wall. In some embodiments of the die system, the first inner diameter of the container side wall is no more than 0.004 inches greater than the second inner diameter of the container side wall.

The necking die **16**, illustrated in FIG. **3**, has a working surface **26** comprising a land **28** a neck radius portion **40** and shoulder radius portion **42**. A relief **38** is also shown. The land **28** is between the neck radius portion **48** and the relief **38**. The inner diameters of the neck radius portion **40** and the shoulder radius portion **42** are greater than the inner diameter of the land **28**. The inner diameter of the land **28** is a minimum diameter of the necking die **16**.

As shown in FIG. **4**, the knockout **18** has a support surface **20**. The support surface **20** has a first knockout outer diameter **30** capable of supporting the first inner diameter **22** of the container side wall **14** when the knockout **18** is inserted into the opening **12** of the metal container **10** and when the metal container **10** is being necked with the necking die **16**; and a second knockout outer diameter **32** capable of supporting the second inner diameter **24** of the container side wall **14** when the knockout **18** is inserted into the opening **12** of the metal container **10** and when the metal container **10** is being necked with the necking die **16**. As can be observed in FIG. **4**, the first knockout outer diameter **30** is larger than the second knockout outer diameter **32**. However, the first knockout outer diameter **30** is capable of passing through the second inner diameter **24** of the side wall **14** after necking when extracting the knockout **18** from the metal container **10**. Even though the first knockout outer diameter **30** is larger than the second inner diameter **24** of the side wall **14** after necking, the first knockout outer diameter **30** is capable of passing through the second inner diameter **24** of the side wall **14** after necking without damaging the metal container **10** because there will be a certain degree of spring-back in the side wall **14** of the metal container **10**. The amount of spring-back will be determined by the thickness, temper, diameter of the container, and alloy of the metal comprising the metal container **10**. The first knockout outer diameter **30** is at least 0.001 inches greater than the second knockout outer diameter **24**. In some embodiments the first knockout outer diameter is at least 0.0015 inches greater than the second knockout outer diameter. In some embodiments, the first knockout outer diameter is at least 0.002 inches greater than the second knockout outer diameter. In some embodiments, the first knockout outer diameter is at least 0.0025 inches greater than the second knockout outer diameter. In some embodiments, the first knockout outer diameter is at least 0.003 inches greater than the second knockout outer diameter. In some embodiments, the first knockout outer diameter is at least 0.004 inches greater than the second knockout outer diameter.

In some embodiments of the die system, the first knockout outer diameter is no more than 0.0060 inches greater than the second knockout outer diameter. In some embodiments of the die system, the first knockout outer diameter is no more than 0.005 inches greater than the second knockout outer diameter. In some embodiments of the die system, the first knockout outer diameter is no more than 0.004 inches greater than the second knockout outer diameter.

As can be observed in FIGS. **5** and **6**, the transition **36** between the first inner diameter **22** of the container side wall **14** and the second inner diameter **24** of the container side wall **14** substantially matches the transition **39** between the first knockout outer diameter **30** and the second knockout outer diameter **32**.

In operation of the die system **1**, in FIG. **1**, to neck the metal container **10**, according to one embodiment, the knockout **18** is inserted into the opening **12** of the metal container **10**. Then, the necking die **16** travels over the opening **12** of the metal container **10**. FIG. **5** shows the knockout **18** inside the metal container **10**, with the necking die **16** about to slide over the metal container **10**. As the necking die **16** travels over the opening **12** of the metal container **10**, the first knockout outer diameter **30** supports the first inner diameter **22** of the side wall **14** of the metal container **10** and the second knockout outer diameter **32** supports the second inner diameter **24** of the side wall **14** of the metal container **10**, as shown in FIG. **6**. Then the necking die **16** is removed from the metal container **10**. Finally, the knockout **18** is removed from the metal container **10**, wherein when removing the knockout **18** from the

metal container **10** the first knockout outer knockout diameter **20** passes through the second inner diameter **24** of the side wall **14**.

In some embodiments, the necking die **16** begins to travels over the opening **12** of the metal container **10** after the knockout **18** begins to be inserted into the metal container **10** but before the knockout **18** is fully inserted into the metal container **10**.

In some embodiments, the necking die **16** begins to travels over the opening **12** of the metal container **10** after the knockout **18** begins to be inserted into the metal container **10** but before the knockout **18** is fully inserted into the metal container **10**. Once the knockout **18** is fully inserted in to the metal container **10** it stops moving while the necking die **16** completes the end of its stroke and begins to move off of the metal container. Then the knockout **18** exits the metal container **10**.

Alternative embodiments of a metal container **100** and a knockout **180** are shown in FIGS. **7** and **8**, respectively. The metal container **100** has a container side wall **140** and the container side wall has a first inner diameter **220**, a second inner diameter **240** and a third inner diameter **250**. The support surface **200** of the knockout **180** has a first knockout outer diameter **300** capable of supporting the first inner diameter **220** of the container side wall **140** when the knockout **180** is inserted into the opening **120** of the metal container **100** and when the metal container **100** is being necked with a necking die. The support surface **200** of the knockout **180** also has a second knockout outer diameter **320** capable of supporting the second inner diameter **240** of the container side wall **140** when the knockout **180** is inserted into the opening **120** of the metal container **100** and when the metal container **100** is being necked with a necking die. Finally, the support surface **200** has a third knockout outer diameter **325** capable of supporting the third inner diameter **250** of the container side wall **140** when the knockout **180** is inserted into the opening **120** of the metal container **100** and when the metal container **100** is being necked with a necking die.

FIG. **9** shows the knockout **180** inside the metal container **100**, with a necking die **160** about to slide over the metal container **100**. In operation, as the necking die **160** travels over the opening **120** of the metal container **100**, the first knockout outer diameter **300** supports the first inner diameter **220** of the side wall **140** of the metal container **100** and the second knockout outer diameter **320** supports the second inner diameter **240** of the side wall **140** of the metal container **100** and the third knockout outer diameter **325** supports the second inner diameter **250** of the side wall **140** of the metal container **100**, as shown in FIG. **10**.

EXAMPLES

In one example embodiment, the thick wall portion of the metal container is 0.006 inch thick and the thin wall portion of the metal container is 0.004 inch thick. In another example, the thick wall portion of the metal container is 0.008 inch thick and the thin wall portion of the metal container is 0.006 inch thick. In a further example, the thick wall portion of the metal container, comprising a 211 can, is 0.0058 inch thick and the thin wall portion of the metal container is 0.0038 inch thick. In yet another example, the thick wall portion of the metal container is 0.006 inch thick and the thin wall portion of the metal container is 0.0038 inch thick. In a further example, the thick wall portion of the metal container is 0.0058 inch thick and the thin wall portion of the metal container is 0.0048 inch thick. In a final example, the thick wall portion of the metal container, comprising a 211 can, is 0.0063 inch thick and the thin wall portion of the metal container is 0.0041 inch thick.

While various embodiments of the present disclosure have been described in detail, it is apparent that modifications and adaptations of those embodiments will occur to those skilled in the art. However, it is to be expressly understood that such modifications and adaptations are within the spirit and scope of the present disclosure.

All features disclosed in the specification, including the claims, abstracts, and drawings, and all the steps in any method or process disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive. Each feature disclosed in the specification, including the claims, abstract, and drawings, can be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

Any element in a claim that does not explicitly state "means" for performing a specified function or "step" for performing a specified function should not be interpreted as a "means or step for" clause as specified in 35 U.S.C. §112.

The invention claimed is:

1. A die system comprising:

(A) a metal container having:

(i) an opening;

(ii) a container side wall, wherein the container side wall has:

(a) a first inner diameter; and

(b) a second inner diameter; and

(c) a transition between the first inner diameter and the second inner diameter wherein the transition of the metal container has a height;

wherein the first inner diameter of the container side wall is at least 0.001 inches greater than the second inner diameter of the container side wall;

(B) a necking die having a working surface comprising a land; and

(C) a knockout having a support surface, the support surface having:

(i) a first knockout outer diameter capable of supporting the first inner diameter of the container side wall when the knockout is inserted into the opening of the metal container and when the metal container is being necked with the necking die;

(ii) a second knockout outer diameter capable of supporting the second inner diameter of the container side wall when the knockout is inserted into the opening of the metal container and when the metal container is being necked with the necking die, and

wherein the first knockout outer diameter is larger than the second knockout outer diameter; and

(iii) a transition between the first knockout outer diameter and the second knockout outer diameter wherein the transition of the knockout has a height; and

(D) a clearance between the outer diameter of the knockout and the inner diameter of portions of side wall of the metal container to be necked by the necking die when the knockout is inserted into the opening of the metal container, wherein the clearance comprises a distance and wherein the distance between the outer diameter of the knockout and the inner diameter of the container side wall remains constant along the height of the transition of the metal container and along the height of the transition of the knockout.

2. The die system of claim 1 wherein the container side wall has a length and, along the length of the container side wall, the second inner diameter of the container side wall is closer to the opening of the metal container than the first inner diameter of the container side wall.

3. The die system of claim 1 wherein the first knockout outer diameter is capable of passing through the second inner diameter of the side wall after necking when extracting the knockout from the metal container.

4. The die system of claim 1 wherein the first inner diameter of the container side wall is at least 0.002 inches greater than the second inner diameter of the container side wall.

5. The die system of claim 1 wherein the metal container has a closed bottom.

6. The die system of claim 1 wherein the metal container was formed by drawing and ironing.

7. The die system of claim 1 wherein the first knockout outer diameter is at least 0.001 inches greater than the second knockout outer diameter.

8. The die system of claim 1 wherein the first knockout outer diameter is at least 0.002 inches greater than the second knockout outer diameter.

9. The die system of claim 1 wherein the transition between the first inner diameter of the container side wall and the second inner diameter of the container side wall substantially matches the transition between the first knockout outer diameter and the second knockout outer diameter.

10. The die system of claim 1 wherein the container side wall has a third inner diameter and wherein the support surface of the knockout has a third knockout outer diameter capable of supporting the third inner diameter of the container side wall when the knockout is inserted into the opening of the metal container and when the metal container is being necked with the necking die.

11. A method of necking a metal container comprising:

(A) moving a necking die over an open end of a metal container, wherein the necking die comprises a working surface having a land, and wherein the metal container comprises;

(i) an opening; and

(ii) a side wall,

wherein the side wall has:

(a) a first inner diameter;

(b) a second inner diameter; and

(c) a transition between the first inner diameter and the second inner diameter, wherein the transition of the metal container has a height;

wherein the first inner diameter is at least 0.001 inches greater than the second inner diameter;

(B) Inserting a knockout into the opening of the metal container, wherein the knockout comprises:

(i) a first knockout outer diameter capable of supporting the first inner diameter of the side wall when the knockout is inserted into the opening of the metal container and when the necking die is over the open end of the metal container;

(ii) a second knockout outer diameter capable of supporting the second inner diameter of the side wall when the knockout is inserted into the opening of the metal container and when the necking die is over the open end of the metal container,

wherein the first knockout outer diameter is larger than the second knockout outer diameter; and

(iii) a transition between the first knockout outer diameter and the second knockout outer diameter wherein the transition of the knockout has a height; and

wherein there is a clearance between the outer diameter of the knockout and the inner diameter of portions of side wall of the metal container to be necked by the necking die, wherein the clearance comprises a distance and wherein the distance between the outer diameter of the knockout and the inner diameter of the container side wall remains constant along the height of the transition of the metal container and along the height of the transition of the knockout;

(C) removing the necking die from the metal container; and

(E) removing the knockout from the metal container;

wherein when removing the knockout from the metal container the first knockout outer knockout diameter passes through the second inner diameter of the side wall.

12. The method of claim 11 wherein the inserting the knockout step (B) occurs before the moving the necking die over the open end of the metal container step (A).

13. The method of claim 11 wherein the removing the necking die from the metal container step (C) occurs before the removing the knockout from the metal container step (D).

14. The method of claim 11 wherein the container side wall has a length and, along the length of the container side wall, the second inner diameter of the container side wall is closer to the opening of the metal container than the first inner diameter of the container side wall.

15. The method of claim 11 wherein the first inner diameter of the container side wall is at least 0.002 inches greater than the second inner diameter of the container side wall.

16. The method of claim 11 wherein the metal container has a closed bottom.

17. The method of claim 11 wherein the metal container was formed by drawing and ironing.

18. The method of claim 11 wherein the first knockout outer diameter is at least 0.001 inches greater than the second knockout outer diameter.

19. The method of claim 11 wherein the first knockout outer diameter is at least 0.002 inches greater than the second knockout outer diameter.

20. The method of claim 11 wherein the transition between the first inner diameter of the container side wall and the second inner diameter of the container side wall substantially matches the transition between the first knockout outer diameter and the second knockout outer diameter.

21. The method of claim 11 wherein the container side wall has a third inner diameter and wherein the support surface of the knockout has a third knockout outer diameter capable of supporting the third inner diameter of the container side wall when the knockout is inserted into the opening of the metal container and when the metal container is being necked with the necking die.

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